UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

November 2010

EBS 417/3 – Geomechanics
[Geomekanik]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains TWELVE printed pages and TWO pages APPENDIXES before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi DUA BELAS muka surat yang bercetak dan DUA muka surat LAMPIRAN sebelum anda memulakan peperiksaan ini.]

This paper consists of TWO questions from PART A and FOUR questions from PART B.
[Kertas soalan ini mengandungi DUA soalan dari BAHAGIAN A dan EMPAT soalan dari BAHAGIAN B.]

Instruction: Answer **ALL** questions from PART A and **THREE** questions from PART B. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **SEMUA** soalan dari BAHAGIAN A dan **TIGA** soalan dari BAHAGIAN B. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

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PART A / *BAHAGIAN A*

1. [a] The results on sieve analysis on soil are:

Sieve size (mm)	Mass retained (g)
50.00	0
37.50	15.5
20.00	17.0
14.00	10.0
10.00	11.0
6.30	33.0
3.35	114.5
1.18	63.3
0.60	18.2
0.15	17.0
0.063	10.5

The total mass of the sample is 311g, plot the particle size distribution curve and, inspect the curve, determine the effective size and uniformity coefficient. Classify the soil based on the chart in Appendix 1.

Keputusan analisa saringan ke atas suatu tanah ialah:

Saiz saringan (mm)	*Jisim yang tertinggal (g)*
50.00	*0*
37.50	*15.5*
20.00	*17.0*
14.00	*10.0*
10.00	*11.0*
6.30	*33.0*
3.35	*114.5*
1.18	*63.3*
0.60	*18.2*
0.15	*17.0*
0.063	*10.5*

Jumlah jisim sampel ialah 311, plotkan lengkuk taburan saiz partikel dan, periksa lengkuk ini serta tentukan saiz keberkesanan dan pekali keseragaman. Kelaskan tanah ini berdasarkan carta di Lampiran 1.

(15 marks/*markah*)

[b] Define the following:

(i) Porosity

(ii) Void Ratio

(iii) Well graded soil

(iv) Uniformly graded soil

(v) Gap graded soil

Takrifkan perkara berikut

(i) keliangan

(ii) nisbah lompang

(iii) tanah bergred rapi

(iv) tanah bergred seragam

(v) tanah bergred sela

(5 marks/*markah*)

2. [a] Define and discuss the following:

(i) Rock mass

(ii) RMR

(iii) RQD

(iv) Strike and dip direction

(v) *In-situ* stress

Takrif dan terangkan mengenai perkara-perkara berikut:

(i) Jisim batuan

(ii) RMR

(iii) RQD

(iv) Jurus dan arah kemiringan

(v) Tegasan in-situ

(10 marks/*markah*)

[b] Write short notes about the common rock slope failures. Illustrate with sketches of the slope and the stereographic projection of each failure.

Tuliskan nota ringkas mengenai kegagalan batuan yang biasa terjadi. Tunjukkan dengan lakaran dan unjuran stereografi bagi setiap kumpulan.

(10 marks/*markah*)

PART B / *BAHAGIAN B*

3. [a] In pumping out test as shown in Figure 1, water is pumped out from a well at the rate of q and the height of water level at the first observation well at distance r1 from the center of the pumping well is h1 and the water level at the second observation well at r2 from the pumping well is h2. Derive the coefficient of permeability:

Dalam ujian pengepaman keluar seperti yang ditunjukkan dalam Rajah 1, air dipam keluar daripada sebuah telaga pada kadar alir q dan ketinggian paras air di telaga pemerhatian pertama dengan jarak r1 daripada titik tengah telaga yang mengepam ialah h1 dan paras air di telaga pemerhatian kedua pada r2 dari telah pengepaman ialah h2. Terbitkan pekali kebolehtelapan:

$$k\frac{2.3q\log_{10}\left(\frac{r_2}{r_1}\right)}{\pi(h_2^2-h_1^2)}$$

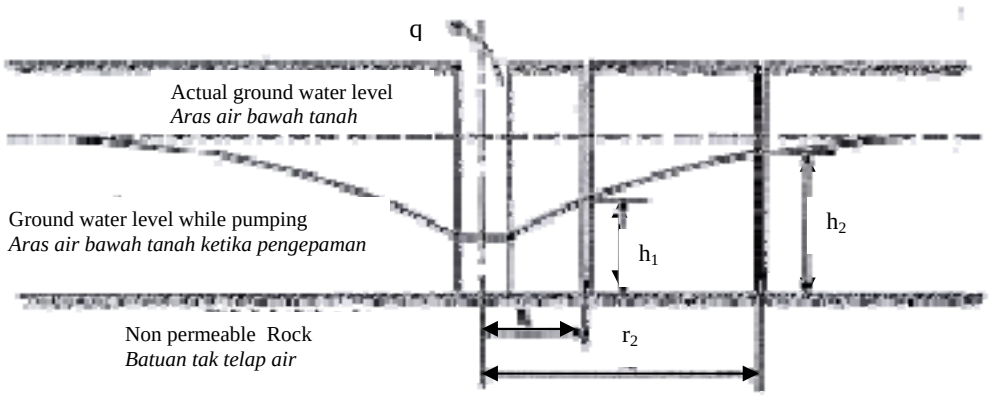

Figure 1 / *Rajah 1*

(5 marks/*markah*)

[b] State and describe corrective measures for failing soul slopes.

Nyatakan dan terangkan langkah pemulihan untuk cerun yang gagal.

(15 marks/*markah*)

4. [a] Define:

(i) total stress

(ii) effective stress

(iii) induced stress

Takrifkan

(i) tegasan jumlah

(ii) tegasan berkesan

(iii) tegasan aruhan

(6 marks/*markah*)

[b] A concrete dam as shown in Figure 2 is constructed over a soil with a sloping impervious bedrock, and a cut-off wall is positioned as shown to reduce seepage. Determine the seepage per day per meter length of the dam if k for the underlying soil is 3 x 10-3 mm/s. Sketch the uplift pressure diagram and give the pressure at points A, B and C.

Sebuah empangan konkrit seperti ditunjukkan di dalam Rajah 2 dibina di atas tanah dengan batuan hampar yang mencerun, dan suatu dinding penghalang diletakkan di bawah empangan untuk mengurangkan resapan. Tentukan resapan per hari per meter panjang empangan sekiranya nilai k untuk tanah ialah 3 x 10-3 mm/s. Lakar rajah tekanan angkat atas, dan berikan tekanan di titik A, B dan C.

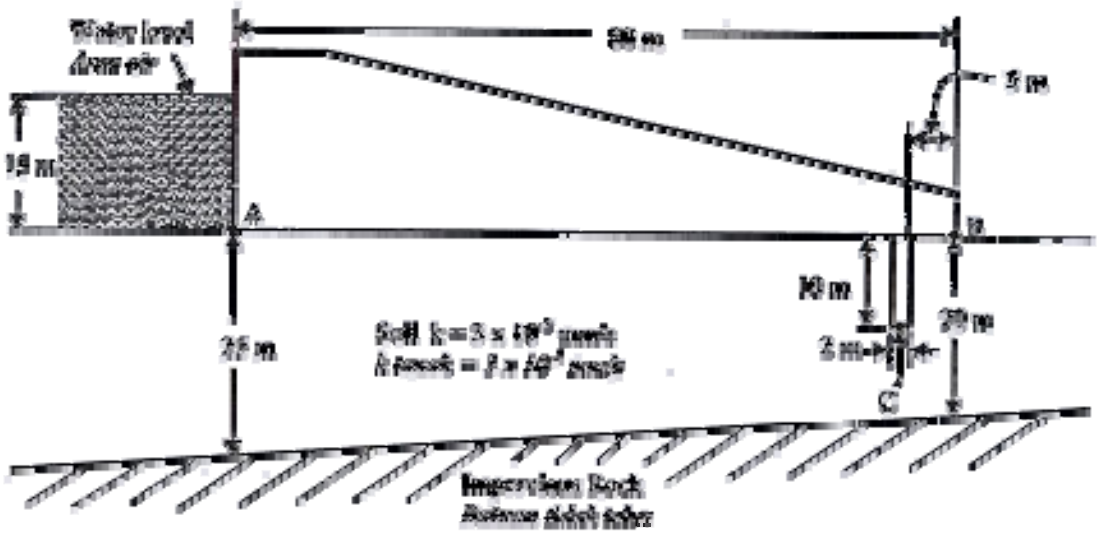

Figure 2 / *Rajah 2*

(14 marks/*markah*)

5. [a] Describe briefly the Mohr-Coulomb failure criterion used in rocks.

Terangkan dengan ringkas kriteria kegagalan Mohr-Coulomb dalam batuan.

(4 marks/*markah*)

[b] Plot the poles of the following discontinuities using stereographic diagram as enclosed in Appendix 1:

(i) dip 10º towards 030º

(ii) dip 20º towards 035º

(iii) dip 21º towards 032º

(iv) dip 15º towards 031º

(v) dip 14º towards 032º

Estimate the dip and trend of these structures.

Plot kutub-kutub ketakselanjaran berikut seperti yang disertakan dalam Lampiran 1:

(i) miring 10º ke arah 030º

(ii) miring 20º ke arah 035º

(iii) miring 21º ke arah 032º

(iv) miring 15º ke arah 031º

(v) miring 14º ke arah 032º

Anggarkan kemiringan am dan tren struktur-struktur ini.

(6 marks/*markah*)

[c] A road is going to be constructed through a granite hill. The rock slope of the road is going to dipping towards 300º. The rock has two sets of joint as follow:

Set 1: dips 52º towards 258º

Set 2: dips 60º towards 333º

The angles of the road cut are being considered at the following angles:

(i) 60º

(ii) 52º

(iii) 40º

Comments on the type of failures (if any) that may occur on each proposed slope

What is the steepest slope that you would recommend and why? Attach all tracing papers used with your answers.

Sebuah jalan raya akan dibina dan akan memotong sebahagian daripada sebuah bukit granit. Cerun di tepi jalan raya ini miring ke arah 300º. Batuan yang akan dipotong ini terdapat dua kekar iaitu:

Set 1: miring 52º ke arah 258º
Set 2: miring 60º ke arah 333º

Sudut muka cerun potongan ini sedang dipertimbangkan seperti berikut:

(i) 60º
(ii) 52º
(iii) 40º

Beri komen anda mengenai jenis kegagalan (jika ada) yang mungkin terjadi pada setiap sudut muka cerun yang dicadangkan.

Apakah sudut muka cerun yang paling curam yang anda syorkan dan nyatakan Mengapa? Jawapan anda hendaklah disertakan dengan kertas surih yang anda gunakan.

(10 marks/*markah*)

6. [a] Explain how rock mass characterization techniques can be used by site engineers to determine the method of excavation and support design system of mine during pre-development.

Terangkan bagaimana teknik pengelasan batuan boleh digunakan oleh jurutera lapangan untuk menentukan teknik pengorekan dan sistem bantuan ke atas lombong semasa pra-pembangunan.

(10 marks/*markah*)

[b] A tunnel of 10 m diameter is to be driven in a granitic rocks mass. The tunnel is penetrated such that the dominant joint set strikes perpendicular to the tunnel axis with a dip of 30^{o} against the drive direction. Classify the rock mass using the information in Table 1 below and the RMR system as enclosed in Appendix 2.

Table 1

Classification parameters	**Value or description**
Uniaxial Compressive Strength, σ_c	125 MPa
RQD	85%
Condition of joints	Rough & plannar, separation < 1 mm, tight, slightly weathered and mostly longer than 3 m Fresh joint wall rock
Joint spacing	0.2 – 0.4 m
Groundwater	Damp

Sebuah terowong 10 m diameter akan di tebuk di dalam jisim batuan granit. Terowong ini akan dibina dengan jurus bagi satu set kekar utama adalah serenjang dengan paksi terowong dan berkemiringan 30^o melawan arah terowong dikorek. Kelaskan jisim batuan ini dengan menggunakan maklumat seperti di Jadual 1 dan menggunakan RMR sistem seperti yang disertakan dalam Lampiran 2.

Jadual 1

Parameter Pengelasan	***Nilai atau penerangan***
Kekuatan bahan utuh, σ_c	*125 MPa*
RQD	*85%*
Keadaan kekar	*Permukaan kasar & rata, bukaan kekar < 1 mm, ketat, sedikit luluhawa dan panjang dari 3 m*
	Dinding batuan kekar segar
Jarak kekar	*0.2 – 0.4 m*
Air bawah tanah	*Lembap*

(10 marks/*markah*)

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APPENDIX 1 / ***LAMPIRAN 1***

Stereographic diagram

APPENDIX 2 / ***LAMPIRAN 2***

Rock Mass Rating System (After Bieniawski, 1989)

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS									
Parameter			Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality *RQD*		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6 - 2 . m	200 - 600 mm	60 - 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10 m tunnel length (l/m)	None	< 10	10 - 25	25 - 125	> 125		
		(Joint water press)/ (Major principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)						
Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS					
Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES					
Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions					
Discontinuity length (persistence) Rating	< 1 m 6	1 - 3 m 4	3 - 10 m 2	10 - 20 m 1	> 20 m 0
Separation (aperture) Rating	None 6	< 0.1 mm 5	0.1 - 1.0 mm 4	1 - 5 mm 1	> 5 mm 0
Roughness Rating	Very rough 6	Rough 5	Slightly rough 3	Smooth 1	Slickensided 0
Infilling (gouge) Rating	None 6	Hard filling < 5 mm 4	Hard filling > 5 mm 2	Soft filling < 5 mm 2	Soft filling > 5 mm 0
Weathering Ratings	Unweathered 6	Slightly weathered 5	Moderately weathered 3	Highly weathered 1	Decomposed 0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**			
Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike°	
Fair	Unfavourable	Fair	

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly.

** Modified after Wickham et al (1972).